

# Decentralized Finance for Actuaries

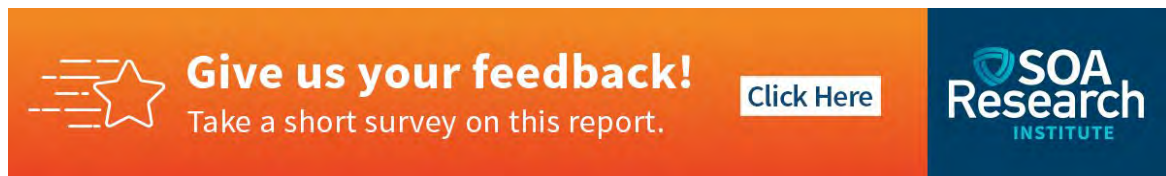



# Decentralized Finance for Actuaries


## A Blockchain-Based Financial System

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## Section 1: Introduction

Decentralized finance, or DeFi, is an emerging financial system powered by blockchain technology. This research report aims to introduce actuaries to DeFi and help them develop a solid understanding of DeFi. It will begin with addressing “what is DeFi?” by providing an introduction on blockchains and DeFi. It will then discuss in further detail the key characteristics, applications, opportunities, and risks of DeFi. After providing the foundation, this report will discuss the potential adoption of DeFi and its interaction with the current financial system (sometimes referred to as traditional finance for contrast with DeFi), and the implications for practicing and aspiring actuaries. In addition, a glossary of terms used in DeFi and a brief history of the development of DeFi have been included in the appendix.

The effect of a technology tends to be overestimated in the short run and underestimated in the long run. The views of the authors are that the impact of DeFi has yet to be fully realized. DeFi has the potential to revolutionize the financial system, similar to how the internet revolutionized information sharing. Beyond its potential impact on the financial system, DeFi can be considered the beginning of a new generation of internet applications that are owned by builders and users known as “Web3.” The authors believe that actuaries with an innovative mindset could benefit from developing an understanding of DeFi.

## Section 2: What is DeFi?

Decentralized finance consists of decentralized applications or protocols that deliver financial applications and services, such as lending, borrowing, and trading.

This section will provide:

- A brief primer on blockchain;
- An introduction to DeFi; and
- A brief discussion on the growth of DeFi (at the time of this writing).

### 2.1 A BRIEF INTRODUCTION TO BLOCKCHAIN

A blockchain is a distributed database where the information is duplicated and distributed across an entire network of computers rather than a centralized entity, making it tamper-proof and transparent. Bitcoin, the first blockchain that gained popularity, executes basic transactions such as payments, and stores ownership information and transaction data.

Some blockchains, such as Bitcoin, primarily verify ownership information and record transactions. Other blockchains, such as Ethereum, can be used for general programming. In these environments, anything that can be embedded in digital code, from transactions, agreements and contracts to business logic and activities, can be executed, verified, stored, and shared in a transparent and immutable manner. Blockchains may use different forms of cryptographic proof for security. The best-known mechanisms in the context of cryptocurrencies are Proof-of-Work and Proof-of-Stake.

A user can begin directly interacting with a blockchain by using a crypto wallet. A wallet is used to store identifying information (known as keys) required to perform transactions on the blockchain. These wallets are typically funded through cryptocurrencies, also known as “tokens,” which represent assets on blockchains purchased from a centralized exchange, such as Binance or Coinbase.

### 2.2 A BRIEF INTRODUCTION TO DEFI

DeFi is an emerging financial system built on public and permissionless blockchains. Newer generations of blockchains can execute complicated transactions using smart contracts, which are computer programs stored on the blockchain that are self-executing when predetermined conditions are met. These smart contracts enable:

- The performance of many traditional financial functions in DeFi, such as depositing assets to earn interest, obtaining loans, and trading assets and derivatives;
- The creation of crypto assets;
- The execution of agreements, business logic and activities on the blockchain.

Acting as financial institutions on blockchains, decentralized applications known as “DeFi dApps” or “DeFi protocols” carry out business activities using smart contracts in lieu of custodial services provided by intermediaries in traditional finance. These decentralized applications rely on users to engage in peer-to-peer (P2P) activities such as providing liquidity and engaging in the governance of the protocol.

The fundamental activities of a protocol are incentivized in various ways such as revenue sharing and liquidity mining. Attracting liquidity is a very important task for many DeFi protocols because a good amount of liquidity is needed for trading activities to flourish, and it reflects the market’s confidence in a protocol. The practice of providing liquidity for reward tokens is known as “liquidity mining” or “yield farming.” More established protocols

tend to be less volatile and have lower advertised rates of return. The sustainability of returns and their effectiveness in attracting and retaining users are relevant to an area of study of the economics of cryptocurrencies, known as tokenomics, which is outside of the scope of this report. A discussion of activities that generate investment returns can be found in Section 5.

Decentralized applications are built using smart contracts. Smart contracts are computer programs stored on the blockchain that are self-executing when predetermined conditions are met. Smart contracts sometimes use off-chain information such as asset price information from centralized exchanges, relayed by services called oracles. Furthermore, applications can easily interact with each other thanks to common technical standards<sup>1</sup>, giving rise to more applications that build on top of others.

One facilitator of DeFi is the presence of stablecoins. Stablecoins are tradable instruments on blockchains that have their value pegged to fiat (non-crypto) currencies, most commonly U.S. dollars. Stablecoins shelter users from the high volatility of crypto asset prices, while allowing users to take advantage of the benefits of DeFi. They also serve as a common form of liquidity between protocols, providing a path for growth for established and emerging protocols alike.

## 2.3 THE GROWTH OF DEFI

DeFi has experienced explosive growth in the last two years. According to Defi Llama, a DeFi data aggregator, DeFi protocols in aggregate have over USD \$245 billion deposited into decentralized financial applications on blockchains as of the end of 2021. This is known as the total value locked (TVL), which could be considered similar to assets under management in traditional finance. In dollar terms, this measure can be quite volatile depending on the price of cryptocurrencies, and it is not distributed evenly across protocols. Seven leading protocols each have over USD \$10 billion locked, while over 500 DeFi protocols have at least USD \$1 million locked (Defi Llama, 2021). Given the increasing attention being paid to this space and continued innovation, DeFi has enormous potential to grow and evolve.

## 2.4 WHY EMBRACE DEFI?

DeFi is a rapidly developing open financial ecosystem enabled by blockchains and smart contracts. The DeFi ecosystem delivers a wide range of financial services accessible to all without traditional intermediaries. Most importantly, DeFi allows participants to have ownership and control over the technology that they use, which has enabled a new and emerging digital economy based on tokens.

A quote from Vitalik Buterin, inventor of Ethereum, highlights the attractiveness of DeFi and Web3: "Whereas most technologies tend to automate workers on the periphery doing menial tasks, blockchains automate away the center. Instead of putting the taxi driver out of a job, blockchain puts Uber out of a job and lets the taxi drivers work with the customer directly" (Buterin, 23 Fascinating Bitcoin And Blockchain Quotes Everyone Should Read, 2018).

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<sup>1</sup> One notable standard is the ERC-20 for creating tokens. This standard allows decentralized trading platforms to emerge, greatly contributing to the development of DeFi.

## Section 3: Key Characteristics of DeFi

In this section, we describe the key characteristics of DeFi and attempt to provide a balanced discussion covering both advantages and disadvantages given the current state of affairs. In summary, DeFi is:

- Disintermediated – DeFi uses smart contracts rather than intermediaries to deliver services.
- Decentralized – The technical infrastructure of DeFi and many governance processes in DeFi are run by decentralized parties.
- Permissionless – Everyone can participate in DeFi. Developers can freely create, and users can freely access the financial services without obtaining permission.
- Composable – DeFi protocols can interact with each other and be built on top of each other.
- Transparent and immutable – Transactions and balances in DeFi can be viewed by everyone and cannot be changed retroactively.

### 3.1 DISINTERMEDIATED

Instead of having to go through a centralized intermediary such as a bank or brokerage, DeFi users can perform financial transactions and receive financial services through smart contracts on a blockchain. Therefore, DeFi is disintermediated. “Trustless” is a common term to describe blockchain technology because, instead of trusting a third party, e.g., sending funds to a specific bank and trusting the bank to handle the transaction properly, one only needs to trust the blockchain and the code of the smart contracts executing the transactions, which can be verified by anyone.

In theory, the elimination of middlemen and back-office work such as verifying transactions significantly reduces overhead costs. Because the system is disintermediated and code-driven, it is highly autonomous and requires limited or, in some cases, no maintenance and intervention, resulting in very limited operating costs. In practice, transactions on blockchains have a cost known as “gas fees,”<sup>2</sup> which can be expensive, depending on the blockchain, and even exceed the value of the transaction in some cases.

The disadvantage of placing trust in code is that smart contracts and blockchains themselves are not foolproof. While many smart contracts are audited, there remain residual risks that users are exposed to. More discussion of risks in DeFi can be found in Section 5.3.

### 3.2 DECENTRALIZED

Decentralization lessens the risks of central point failures and regulatory uncertainties<sup>3</sup>, and empowers adopters of decentralized technology and services. There are broadly two forms of decentralization in DeFi. The foundational form is in the blockchain itself. Transactions need to be verified and added to the blockchain by miners and validators, often in a decentralized manner. There is no single database maintained by a central entity, but rather a public ledger distributed and replicated on many individual physical computers.

The second form of decentralization concerns on-chain activities. Many protocols adopt a governance structure known as a decentralized autonomous organization (DAO), where protocols’ governance token holders discuss proposals and vote to make decisions collectively which are then carried out in a public, transparent manner. This is sometimes enforced through smart contracts while in other situations it is implemented by a development team

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<sup>2</sup> Gas fees can be understood as computation and transaction fees used to compensate miners and validators who help secure the network.

<sup>3</sup> When an application is built on a decentralized blockchain network, it is harder for an external party to shut down the application because it is not easy to turn off the blockchain without a successful attack. Also, if the applications are built by a decentralized team or organization, it is harder to hold any one party accountable for anything. For example, the risk that a government can seize assets is lower as the assets are not stored in an identifiable centralized organization. However, the regulatory oversight of DeFi is very much uncertain (see section 5.3).

that respects the authority of the DAO. The decisions can range from how the DAO will spend its treasury to how to adjust the tokenomics of the protocol. The DAO structure encourages users to learn and contribute to the protocols and boosts community participation and collaboration.

The major disadvantage of decentralization is added complexity. Instead of a single powerful computer to maintain records, a decentralized network requires many more participants and coordination. Some have argued that the level of decentralization is commonly overstated for both blockchains themselves and the governance of decentralized applications (Chu & Wang, 2018; Gencer, Basu, Eyal, van Renesse, & Gün Sirer, 2018; Nabben, 2021). The lack of a central entity with full access to information also leaves room for sophisticated contract designs that preserve privacy<sup>4</sup>, which could be used to cover the trail of criminal activities.

Also, the current decentralized governance systems are far from flawless. For instance, even though proposal submissions and votes can be decentralized, the implementation of the proposals is often still centralized to the development team.

### 3.3 PERMISSIONLESS

Public blockchains are open to anyone; so is decentralized finance. In theory, anyone with an internet connection can participate in on-chain activities such as interacting with dApps and deploying new applications. This implies decentralized finance is borderless. Users around the world can participate in the same network and dApps (subject to legal restrictions, if any). Many see DeFi as an opportunity to “bank the unbanked” (Jones, 2021), allowing users to observe and participate in activities that would not have been available to them in traditional systems due to capital requirements and other barriers.

Permissionless also means that there is a low barrier to entry. This allows for development cycles in DeFi to be short. In DeFi, anyone with knowledge and skills can design, develop and deploy applications on-chain and have instant access to secure robust infrastructure with millions of potential users. Uniswap, a major decentralized exchange (DEX)<sup>5</sup>, was famously written by a solo developer with limited blockchain experience at the time (Hayden, 2018).

Although blockchains and smart contracts are permissionless in theory, hurdles prevent them from being truly permissionless in practice. These include the process of moving capital from off-chain to on-chain, typically done by converting conventional fiat currencies into crypto assets using an “on-ramp” exchange. Most of these services require a “Know Your Client” (KYC) identity verification, and some financial institutions may even disallow users from sending assets to crypto on-ramp services. Some countries have outright banned crypto activities (BBC News, 2021). Not everything is permission-free on-chain either. In order to reduce regulatory burdens, some dApps restrict user actions based on citizenship and residency (Defi Prime, 2019; 1inch Team, 2021).

### 3.4 COMPOSABLE

Composability refers to the ability for dApps to communicate with each other and build on top of each other (Buterin, Cross-shard DeFi composability, 2019). Composability, sometimes referred to as “money Lego,” is a feature of DeFi that enables creative and efficient financial products and promotes capital efficiency that is difficult to replicate in traditional financial systems. For example, one can provide liquidity to a DEX, obtain a liquidity provider (LP) token<sup>6</sup> as a receipt, and deposit the LP token somewhere else as collateral for borrowing. This is only possible because asset positions are represented as standardized tokens, most commonly under the ERC20 standard used on

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<sup>4</sup> One example is Tornado Cash on Ethereum. <https://tornado.cash/>

<sup>5</sup> Decentralized exchanges are DeFi applications that allow cryptocurrency transactions without an intermediary.

<sup>6</sup> LP (Liquidity Provider) tokens act as receipts for depositing cryptocurrencies into a smart contract that can be redeemed or used elsewhere.



the Ethereum blockchain and, therefore, all dApps can recognize and interact with these tokens. Developers can easily build new uses for existing contracts and tokens, while users can pursue new opportunities using existing asset positions. As a result, capital efficiency can be very high within DeFi. While similar activities can be done in traditional finance<sup>7</sup>, DeFi reduces the high barrier to entry, such as the level of capital required and need to find a counterparty.

One downside of composability is heightened contagion risks. If one of the protocols or products is compromised, other products that are built on top of it are also at risk.

Another downside is complexity and the resulting implementation risks. There have been multiple exploits related to cross-chain bridges, as well as to integration with other dApps (Rekt, 2021).

### 3.5 TRANSPARENT AND IMMUTABLE

Decentralized finance inherits the transparency and immutability of history from blockchains. Because there is only one immutable, shared history of transactions, accounting risks and costs for reconciliation are significantly reduced in DeFi.

Since all the information is transparent, it is easy to monitor the health and growth of decentralized protocols in real-time through metrics such as total value locked (TVL), number of users, number of transactions, etc. The abundance of on-chain data also opens many opportunities for applying data science techniques to extract insights and improve products<sup>8</sup>.

The code of most smart contracts can be viewed by anyone. Therefore, it is possible for knowledgeable DeFi participants to review and audit smart contracts, perform due diligence or identify arbitrage opportunities. The open-source nature of many protocols also promotes learning from each other and growing together within the ecosystem.

Transparency can be a double-edged sword. Ill-intentioned actors can take advantage of loopholes that could lead to the loss of funds of legitimate users. Also, the GNU General Public License (GPL)<sup>9</sup> used by many open-source projects means that the code of smart contracts can be copied and redeployed by competitors. Competitors can use this code and take market share away from the original developers, thereby reducing their future financial benefit and, potentially, the viability of the original application.

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<sup>7</sup> This ability in DeFi is analogous to emails versus traditional post mail. One can argue that post mails can do everything that emails can do but emails are more convenient to use.

<sup>8</sup> For more information, refer to Dune Analytics, The Graph, Nansen, and Glassnode.

<sup>9</sup> [https://en.wikipedia.org/wiki/GNU\\_General\\_Public\\_License](https://en.wikipedia.org/wiki/GNU_General_Public_License)

## Section 4: Applications of DeFi

A fairly complete financial system has already been developed in DeFi. There are many parallels between traditional finance and DeFi. In this section, we provide an overview of applications that exist in DeFi by their primary functions. Our overview is far from comprehensive and there are new protocols launched daily. We encourage interested readers to explore more protocols using information aggregators such as DeFi Pulse and DeFi Llama.

**Table 1**

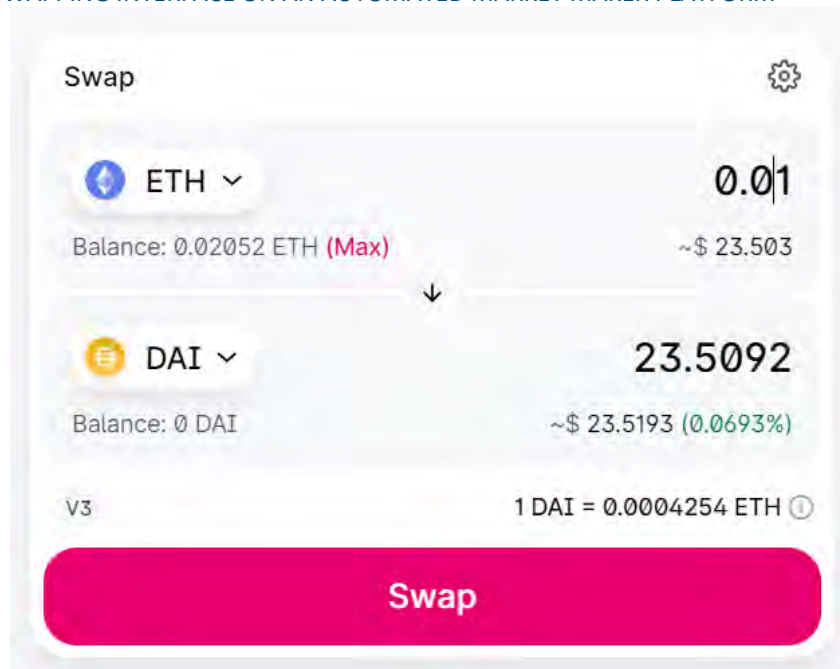
### COMPARISON OF TRADITIONAL FINANCE AND DEFI ON THEIR RESPECTIVE FINANCIAL ACTIVITIES

Financial Activities	Traditional Finance	DeFi Examples
Exchanges	Stock and commodity exchanges	Uniswap / Curve
Lending and borrowing facilitation	Commercial banks	Compound / Aave
Yield aggregation	Asset management companies	Yearn
Risk trading	Derivatives clearinghouses	dYdX
Risk mitigation	Insurance companies	Nexus Mutual

#### 4.1 DECENTRALIZED EXCHANGES

Decentralized exchanges (DEX) allow users to exchange or swap on-chain assets by interacting with smart contracts rather than through a custodial intermediary. This is made possible through decentralized liquidity providing and automated market maker (AMM). In centralized exchanges, the exchange sources and supplies the liquidity to allow for trading. In decentralized exchanges with automate market making, the liquidity is provided by individual “liquidity providers.” Liquidity providers can earn a share of the transaction fees paid by DEX users. Attracting liquidity is arguably one of the greatest challenges for any DeFi protocol. In order to attract liquidity providers and deposits, most platforms also offer liquidity mining programs with both economic and governance incentives on top of revenue sharing (also see Section 2.2. and Section 5.1).

**Figure 1**  
AN EXAMPLE OF SWAPPING INTERFACE ON AN AUTOMATED MARKET MAKER PLATFORM



AMM is an economic algorithm that allows peer-to-peer liquidity provision and token swapping. Unlike order book-based exchanges, buy and sell orders do not need to be matched up. Instead, trade orders are automatically executed using preset swapping and distribution rules from a liquidity pool. AMM was first introduced by Robin Hanson in his paper, “Combinatorial information market design for a prediction market,” and was later modified and used in Bancor and Uniswap to enable crypto token swapping. Bancor and Uniswap are both DEXs that facilitate automated transactions between cryptocurrency tokens on the Ethereum blockchain using smart contracts via an AMM called “constant product market maker” (CPMM). After the initial success of these protocols, different AMMs have been invented such as multi-dimensional CPMM by Balancer, or Stableswap by Curve (Angeris & Chitra, 2020; Berenzon, 2020).

## 4.2 STABLECOINS

Stablecoins are crypto tokens with values pegged to a fiat currency. Despite their simply stated purpose, stablecoins have a great variety of designs with varying levels of risk. Based on a classification proposed by Klages-Mundt, there are two broad categories of stablecoins: custodial (centralized) and non-custodial (decentralized) (Klages-Mundt, Harz, Gudgeon, Liu, & Minca, 2020).

Custodial stablecoins are a digital representation of a reserve asset held off-chain by issuers of the on-chain stablecoins. Tether (USDT), USD Coin (USDC), Binance USD (BUSD), and TrueUSD (TUSD) are all examples of custodial stablecoins with a combined market capitalization of over \$130 billion by the end of 2021.

Non-custodial stablecoins are implemented through smart contracts. A notable example of a non-custodial stablecoin is Dai, created by MakerDAO, with a market capitalization of over \$6 billion. Dai maintains its pegs

through a combination of over-collateralization and economic incentives<sup>10</sup>. Terra USD (UST) is an example of algorithmic stablecoins that maintains its peg by using an elastic monetary policy via a reserve token and miner incentives (Kereiakes, Kwon, & Di Maggio, 2019).

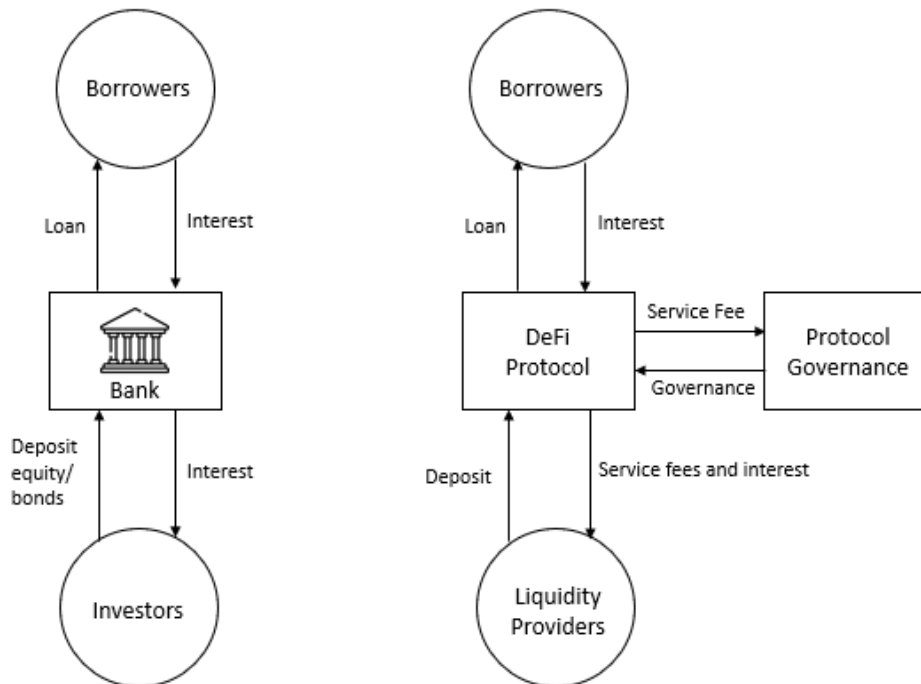
### 4.3 LENDING AND BORROWING

Lending and borrowing DeFi platforms offer crypto-based loans. Most borrowing activities require over-collateralization. If the value of the collateral falls significantly, the borrower risks being liquidated; their collateral is sold to cover their debt. Users can also trade on margin by short-selling or leveraging.

Generally speaking, there are two ways to borrow. The first one is to borrow from existing assets that are provided by lenders or depositors. The second one is to mint new assets from the borrower's collateral. In the first case, depositors provide liquidity to the market to earn a passive return, while borrowers can borrow assets by paying an interest rate. The deposit and borrow interest rates are set programmatically based on market supply and demand<sup>11</sup>. For example, users can borrow USDC from AAVE, and the USDC tokens come from lenders who deposited their USDC into the protocol's smart contracts. In the second case, users can mint new stablecoins (such as DAI) against the collateral they post, and the borrowed assets are created in the process. This is usually how decentralized stablecoins are issued.

Figure 2

#### A COMPARISON OF LENDING VALUE CHAIN BETWEEN TRADITIONAL FINANCIAL INSTITUTIONS AND DEFI



<sup>10</sup> Explained simply, users deposit assets as collateral in order to create, or "mint," stablecoins, or borrow against the underlying collateral. Liquidation could happen if the value of the collateral falls below a pre-set threshold. During liquidation, the collateral is sold at a discount and used to maintain the peg.

<sup>11</sup> Some of the most prominent DeFi protocols are money-market platforms such as Compound and Aave. More recently, Abracadabra gained popularity due to new collateral types such as interest-bearing tokens. Rari Capital designed a Fuse platform that generalizes money markets for any assets.

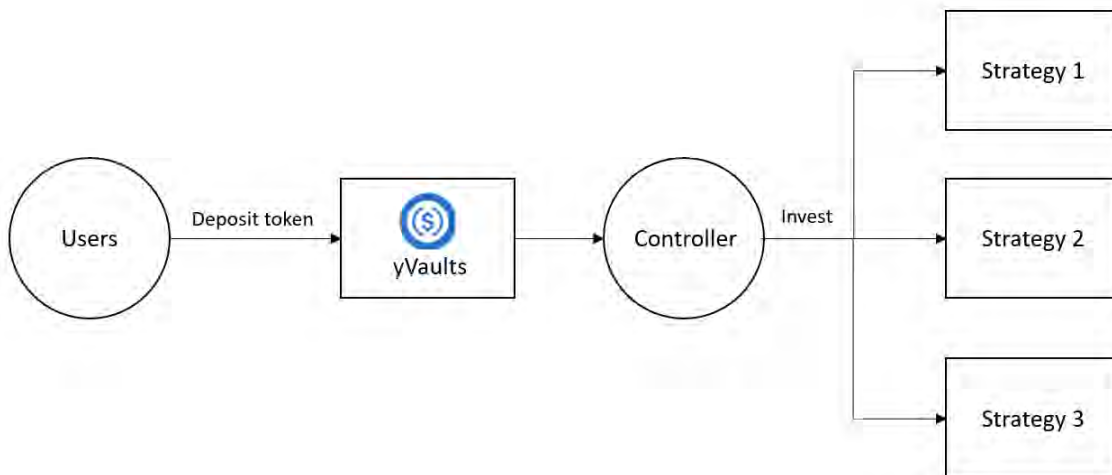
Unique in DeFi, a flash loan is a smart contract-enabled loan that is borrowed and repaid within the same transaction on a blockchain. No collateral is required. This means anyone can have access to nearly unlimited capital within a single transaction, as long as they can afford a small fee (0.30% fee on Aave). Despite the fee, flash loans level the playing field for arbitrageurs by giving them easy access to capital to profit from arbitrage opportunities. The DeFi ecosystem is likely going to be more efficient due to the availability of flash loans. On the other hand, flash loans are often used by ill-intentioned hackers and protocols could fall victim to flash loan attacks (Cao, Zou, & Cheng).

A comprehensive review of DeFi lending can be found in a paper by Gudgeon, et al. on DeFi protocols for loanable funds (Gudgeon, Werner, Perez, & J. Knottenbelt, 2020). However, the DeFi lending market is constantly evolving with many new entrants offering innovative products, such as interest-free loans, self-repaying loans, and loans backed by unconventional assets.

#### 4.4 PORTFOLIO MANAGEMENT

DeFi portfolio management consists of services provided by DeFi protocols to simplify the management of investment portfolios and maximize their returns in DeFi. Given the variety and composability of DeFi protocols, DeFi yield management strategies can be complex and costly to implement due to transaction fees, time, and effort. As a result, portfolio managers were reinvented in DeFi. Decentralized yield aggregators and yield enhancers reduce the cost and simplify the implementation of on-chain portfolio management strategies. These protocols abstract away the complexity of DeFi strategies and enhance risk-adjusted returns for the end-users. They also reduce the cost of transactions by batching transactions for all users. They continue to grow and attract significant capital flow. Some protocols offer specialized services such as auto-compounding rewards, monetizing voting power of governance tokens, and providing crypto index products.

**Figure 3**  
A SUMMARY OF YEARN V2, A YIELD AGGREGATOR<sup>12</sup>



<sup>12</sup> Yearn Vaults, or yVaults, accept user deposits and generate returns, using strategies executed by the controllers of the vaults.

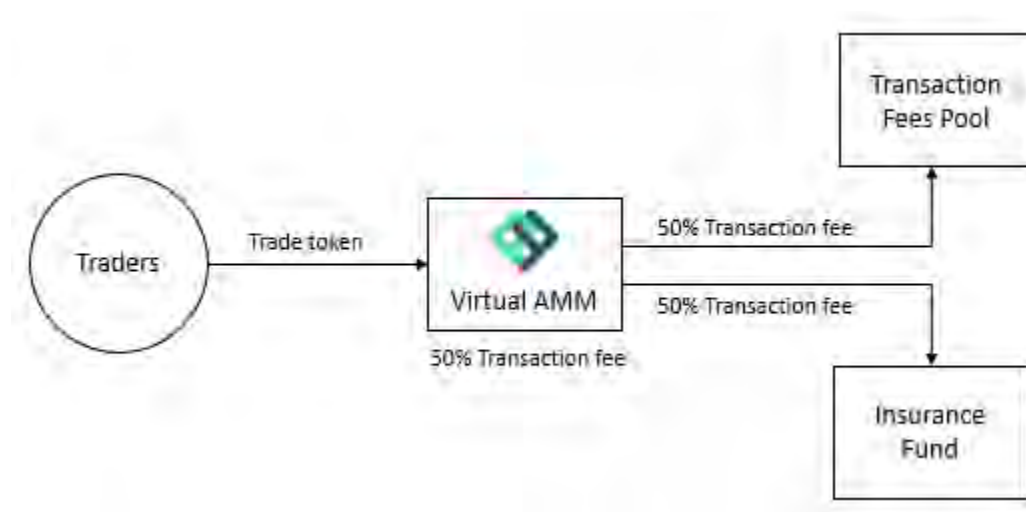
## 4.5 DERIVATIVES

Many financial derivatives have been replicated in DeFi, including synthetic assets, futures, options and swaps. Instead of having a central clearinghouse or central custodian, DeFi users can open and close trading positions by sending instructions to smart contracts. The value of decentralized derivatives is developed from underlying assets.

One prominent example is synthetic assets. Instead of holding the actual assets, users can mint synthetic tokens that provide price exposures to a wide range of assets, including fiat currencies, crypto assets, and a select number of public equities and indices on decentralized platforms such as Synthetix. Users can exchange synthetic assets with very high liquidity. Short positions can also be created using synthetic assets. Other derivatives have also been created on-chain, such as futures and options. Perpetual futures contracts are popularly used for leveraged trading in the crypto space, which are futures contracts that don't have an expiry date. The DeFi options trading market is competitive where multiple platforms allow users to buy and sell simple European or American options and many are building more sophisticated functionalities such as option spread trading and structured yield generation strategies. Interest rate swaps are also an emerging area of development in DeFi.

**Figure 4**

**AN ILLUSTRATION OF THE PERPETUAL PROTOCOL SYSTEM, A DERIVATIVES TRADING PLATFORM**



## 4.6 INSURANCE

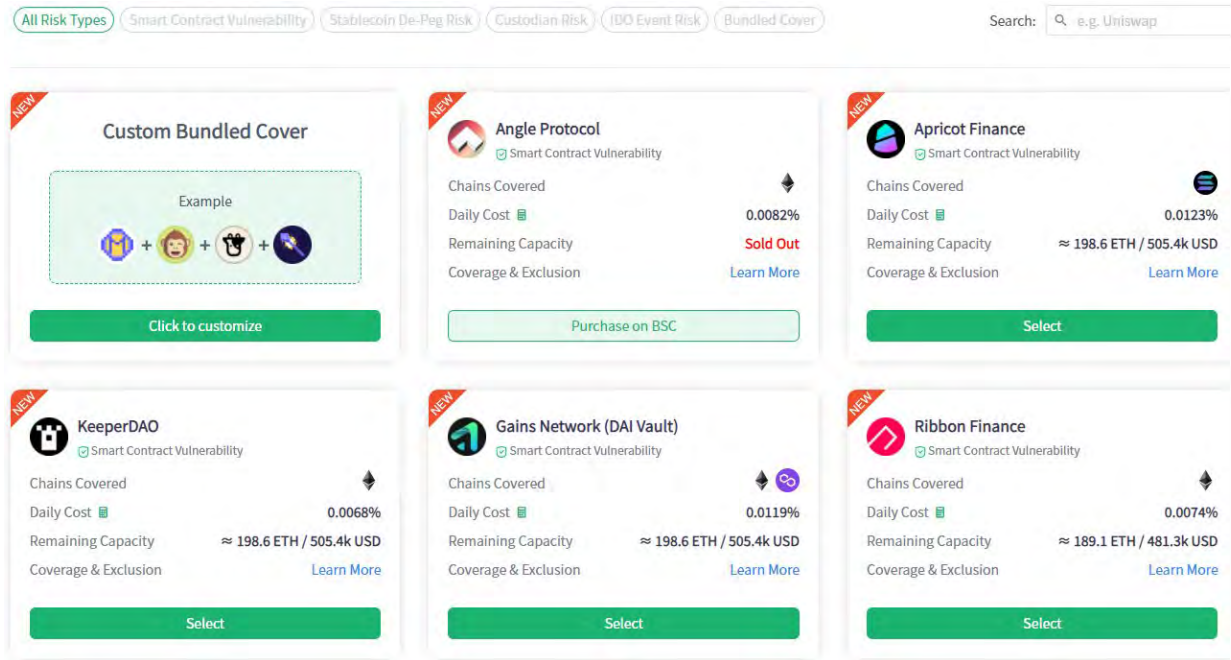
Currently, the majority of the decentralized insurance products are limited to on-chain risks (e.g., stablecoin de-pegging risks, smart contract risks). A small number of projects, such as Etherisc, aim to expand decentralized applications to more traditional insurance products.

The suggested advantages of on-chain insurance or risk-sharing include reduced administrative and governance cost, greater transparency, and streamlined use of data in decision making (Karp, Hugh; Melbardis, Reinis, 2017).

DeFi users can purchase insurance, or “smart contract covers,” to mitigate the risk of suffering financial losses due to hacks and exploits of smart contracts. The quoting of premiums is provided by platforms' front-end websites, and users can purchase covers directly from their crypto wallets in a similar way that they perform other DeFi transactions.

The product offering of DeFi insurance has continued to expand as DeFi ecosystems develop and mature. For example, in addition to basic smart-contract or protocol-code risks, insurance platforms have also started to offer more advanced and comprehensive coverage against various risks.

Figure 5  
THE INTERFACE OF INSURANCE<sup>13</sup>



<sup>13</sup> ACCESSED 28 JANUARY, 2022, [HTTPS://APP.INSURANCE.IO/INSURANCE/BUYCOVERS](https://app.insurance.io/insurance/buycovers)

## Section 5: Opportunities and Risks in DeFi

In this section, we will provide an overview of financial activities that DeFi users can participate in, and break down the sources of yields that are backing the returns of those activities. We will also discuss the risks associated with these opportunities and some mitigation strategies.

### 5.1 INVESTMENT ACTIVITIES IN DEFI

DeFi is commonly known to investors for high returns unheard of in traditional finance. In extreme cases with high risks, the annual percentage returns on volatile assets can be over 1,000%. Even for USD-pegged stablecoins, the current DeFi ecosystem offers higher yields compared to what banks offer on USD in traditional finance, ranging from 1% to over 20% depending on market supply and demand (DeFi Rate).

Questions do arise about whether these yields are sustainable. The yields are partly supported by the alternative business model for financial services offered in DeFi. Instead of physical infrastructures, such as offices and bank branches, DeFi relies solely on digital infrastructure, the blockchain. There is also cost savings from the reduction of most of the costs that a bank faces such as middle management, customer service, and accounting services.

In addition to the cost reduction, DeFi provides sources of yields that are unavailable to most users in the traditional financial system. Most on-chain activities demand users pay a fee to perform that activity. This generates a return for lenders, liquidity providers, service providers (the protocols), and token holders of the protocol. For example, decentralized exchange protocols charge a fee from users when they swap tokens (i.e., swap USDC for ETH or, said differently, buying ETH with USDC), similar to traditional stock exchanges charging a transaction fee for buying and selling stocks. This fee is collected by the protocol and shared with liquidity providers. The volume of services provided by the protocol could support the market valuation of protocol tokens and, therefore, the transaction will also indirectly benefit the token holders of the protocol.

The diverse financial activities that users can participate in opens the door to alternative asset allocation and portfolio management opportunities. The following is a non-exhaustive list of these opportunities with examples and a discussion of sources of yields.

#### Trading and Arbitraging

Similar to stocks in traditional finance, investors can trade cryptocurrencies on centralized or decentralized exchanges for price speculation and to implement trading strategies. Traditional technical analysis tools are also employed in cryptocurrency trading (Detzel, Liu, Strauss, Zhou, & Zhu, 2018). The most common type of trading derivatives in DeFi is perpetual contracts without an expiry date. The price peg to the spot asset is maintained by funding rates paid by one side to the benefit of the other side<sup>14</sup>. Traders will be able to set their own leverage levels for hedging, profit multiplication and other purposes.

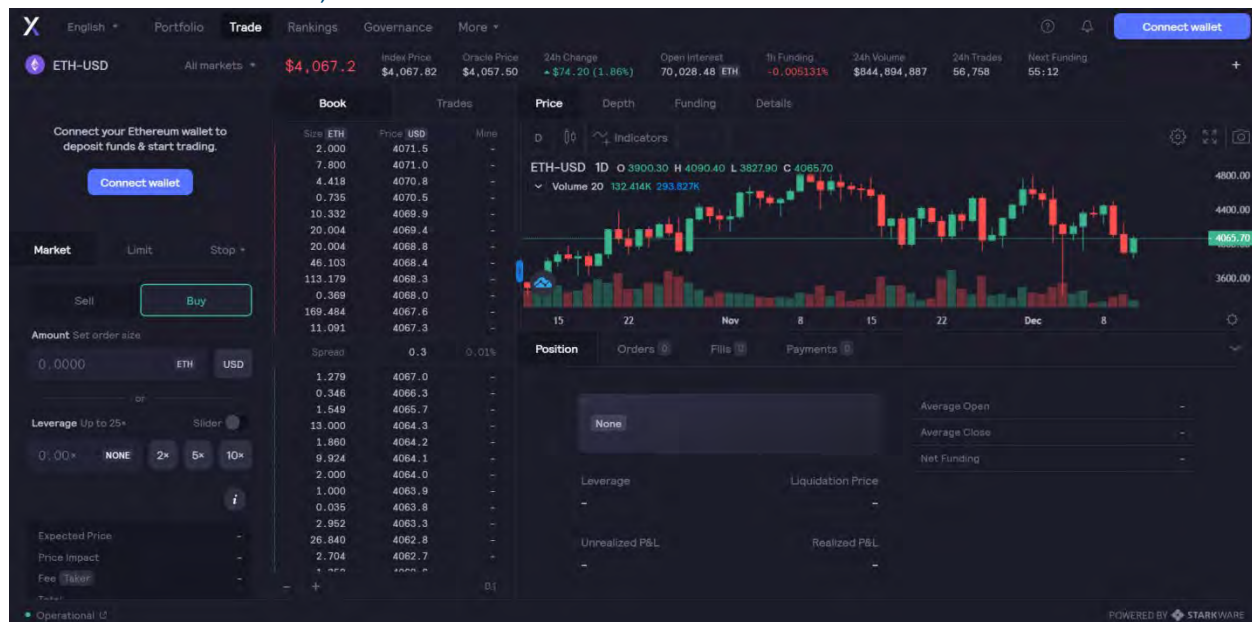
There are also many opportunities for arbitrage actions in DeFi. With flash loans, arbitrageurs can have access to nearly unlimited capital instantly on-chain. Also unique to blockchains, users that help run the network (miners, validators, etc.) have the potential to profit from transaction selection and manipulations. This is commonly called maximum or miner extractable value (MEV).

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<sup>14</sup> When the futures price is above the spot price, a premium will be charged for long positions to fund short positions, thereby incentivizing traders to short and bring the futures price back to the spot price, and vice versa.



**Figure 6**  
**FUTURES TRADING ON DYDX, A FUTURES DEX ON ETHEREUM<sup>15</sup>**



## Staking and Delegating

Staking refers to the practice of locking crypto tokens into smart contracts in order to earn more of those tokens in return (Earning Passive Income with DeFi Staking: An Overview, 2021). One use of staking is to support the security of proof-of-stake blockchains. Users can lock network-native tokens (e.g., ETH for Ethereum, AVAX for Avalanche) to become a validator that performs duties such as proposing, checking and confirming blocks. Validators receive validation rewards based on the value staked and validation activities, generating a source of yield.

There are costs to providing computing powers and possible minimum stake limitations for being a network validator, which arguably leads to unfairness in the network for participants who own less capital upfront. The system of delegation alleviates this problem by allowing those participants to delegate their cryptocurrencies to individual validators and receive a share of the validation rewards.

More broadly, staking can be used by DeFi protocols to incentivize users to hold, rather than sell, a specific token. By staking a token of a protocol, users can expect to receive more of the same token in return. Staking in this context is designed to reward users that support a protocol and hold a protocol token over the long-term. The staked tokens can sometimes be thought of as an emergency fund and can be used to protect the protocol against unexpected loss of funds (Aave Team, 2021).

## Liquidity Provision

Investors, known as liquidity providers, can deposit tokens that can then be traded against other tokens on decentralized exchanges. Users of the decentralized exchanges pay a transaction fee to swap tokens (i.e., exchange token A for an equivalent value in token B) and these fees will then be shared amongst the liquidity providers and the protocol.

To attract liquidity, some liquidity pools issue additional rewards to liquidity providers regardless of transactions. The process of earning reward tokens is referred to as “liquidity mining” or “yield farming.” These tokens often

<sup>15</sup> Accessed 12 December 2021. <https://trade.dydx.exchange>.

come with governance rights, so they effectively support the decentralization of governance when they are distributed to community members. The tokens are designed with their prices aligned with the interests of liquidity providers and the protocol. Some newer blockchains such as Avalanche also incentivize early users using network native tokens (Nansen, 2021).

More recently, a new form of liquidity providing has emerged and it's called bonding. Bonds are often short-term vested protocol tokens sold at a discount in exchange for liquidity-providing receipts (LP tokens). Users purchasing bonds receive rewards in the form of discounted tokens that can be further staked, while the platform will instead own the liquidity (Olympus Pro Team, 2021).

### **Asset Lending**

Lending protocols allow certain cryptocurrencies to be deposited into a pool to be borrowed for various purposes, while interest rates and other fees, such as loan origination fees, are earned in the process by the platform and shared with the lenders. In some cases, the collateral used to back loans can be used to generate further yields.

### **Service Providing**

Protocols provide services to DeFi users, and some users can provide services to protocols. The most prominent examples are in asset management. Yield aggregators charge a performance fee or asset management fee based on the value of assets under management. Index product providers also charge a management fee. Users who provide strategies for yield aggregators may earn a share of those fees.

Advanced users earn financial rewards by performing transactions needed by protocols. For example, the rewards from liquidity mining and lending are typically manually harvested. This poses extra transaction costs for users who wish to compound their stakes. Auto-compounders emerged to provide bundled transactions to harvest, convert and re-stake the rewards simultaneously to save both fees and time for users. Another example of performing services includes liquidating positions for lending protocols (Pertsev, Semenov, Storm, & Kovtonyuk, 2022).

### **Community Incentives**

Many protocols are willing to use token incentives to attract users. Airdrops are free tokens distributed by platforms for marketing purposes or to reward users. Eligible users can claim these tokens to stake or resell for a profit.

Many DeFi protocols adopt a DAO governance structure where owners of tokens of the DAO make decentralized decisions, such as setting parameters for the protocols and allocating treasury capital through voting, and implement those decisions using smart contracts. Users may earn incentives for participating in DAO activities.

## **5.2 NATIVE FINANCIAL SYSTEM FOR A NEW DIGITAL ECONOMY**

A new digital economy for images, videos, music, games, and virtual worlds built on top of blockchain technology is rapidly developing. DeFi serves as the native financial system for this new economy.

Non-fungible tokens, or NFTs, represent ownership of distinct digital valuables. They offer investment opportunities similar to the traditional fine art market, but they can be more easily traded with the use of DeFi. NFTs are highly customizable and can be used to represent any ownership interest, such as musical royalties. The market cap for NFTs has grown over ten-fold since 2018 to nearly half a billion dollars (de Best, 2021). OpenSea, a leading decentralized platform for NFTs, has facilitated over \$1 billion volume of trades in 2021 alone and surpassed \$10 billion in cumulative volumes (Messari, 2021), all settled on decentralized public blockchains.

Combining gaming and finance, GameFi is an emerging industry that focuses on the gamification of monetary policies in play-to-earn games that are built on top of blockchains. Players can play games to obtain digital assets

such as characters, land, and costumes. Because of the use of blockchain technology, ownership of these digital assets can be verified and traced. Axis Infinity, a category-defining crypto game in which players can battle, trade, and collect digital pets and earn digital tokens, has over two million active players (ActivePlayer, 2021) and has reached a sales volume of over \$3 billion (Crypto Slam, 2021).

The development of virtual worlds, or metaverses, is also on the rise and gained mainstream attention from Facebook's decision to rebrand as Meta in October 2021. Decentraland and Sandbox are virtual reality platforms with virtual spaces where users can control environments and create applications built on blockchain technology.

Beyond NFTs, games, and virtual worlds, the idea of maximal user control and ownership can be generalized and applied to more web-based applications. The movement of decentralizing and tokenizing web-based applications is sometimes referred to as web3. The shape and form of these emerging digital initiatives is far from fully developed, however, the commonality is that they are built on blockchains and, therefore, can be powered by DeFi. DeFi is an enabler of the new digital economy similar to how traditional finance enables traditional economic activities.

### 5.3 RISKS IN DEFI

DeFi inherits some risks from blockchain technology as well as other risks. Some of these risks are unique to DeFi that traditional finance participants may not be aware of. They can lead to total losses of initial investments. The intent of this section is to provide readers with an overview of some select risks in DeFi. A comprehensive overview of risks in DeFi and classification framework are out of scope for this report, but we have described some key risks within the section.

**Custodial risks:** Crypto wallets can be accessed and controlled by anyone with their private key. If the private key is lost, even the legitimate owner of the wallet will lose access to the funds. While custodial risks exist in traditional finance, DeFi is unique in that each user retains custody of their own assets. Hackers, phishing attackers, and scammers often try to gain access to users' keys. It is a widespread phenomenon for support teams of dApps on social media to be impersonated by scammers, misleading owners to leak their private keys. Scammers holding the private key can then gain control of the funds. Even well-known centralized exchanges are vulnerable to these attacks (NGRAVE, 2020).

**Price volatility risks:** Crypto assets can be highly volatile (Kyriazis, 2021). Even stablecoins can lose their pegs from time to time and cause users to suffer losses (Klages-Mundt & Minca, 2020). Price volatility could lead to realized financial losses in trading and cause liquidations.

**Smart contract security risks:** It may be a double-edged sword that smart contracts are transparent and self-executing. Sophisticated hackers could exploit security or implementation bugs and issues to gain unauthorized access to the resources managed by the contracts, which could lead to loss of funds for users and protocols (de Sousa, dos Santos, Conceição, & Vijaykumar, 2021).

**Economic security risks:** The economic design of the contracts and protocols can also be flawed and open to attacks (Werner, et al., 2021). Protocols may have loopholes that allow users to extract disproportionate value at the expense of other users or the protocol. Systemic failures, such as de-pegging of stablecoins or depreciation of collateral assets, could also happen due to unstable economic design or poor data sources.

**Systemic contagion risks:** DeFi protocols are highly composable and can be built on top of each other, creating a "money Lego." This also means that the failure of a single protocol or cryptocurrency could create a ripple effect felt across multiple protocols or even the entire ecosystem (Laul, 2021).

**Settlement layer risks:** The blockchains used to settle transactions could malfunction, resulting in temporary or permanent losses of access to on-chain assets. Also, blockchains may be exposed to Sybil attacks<sup>16</sup> depending on their implementation of consensus algorithms, or mechanisms that allow miners and validators to reach agreements.

**Liquidity risks:** Tokens in DeFi could have low-trading volumes and users may be unable to liquidate their holdings at desirable price levels. On DEXes, this manifests as “slippage” where high volume trades will impact trade pricing unfavorably due to the mechanism of AMM.

**Regulatory risks:** Regulators across the globe are grappling with the challenges brought by cryptocurrencies and on-chain transactions. The legal status of cryptocurrencies varies significantly across jurisdictions (World Economic Forum, 2021). From regulators’ perspectives, cryptocurrencies introduce new and unique risks to the financial system and could jeopardize consumer interests and the health of the economy. As a result, crypto users are vulnerable to various regulatory measures: in some jurisdictions, restrictive measures or outright bans could lead to crypto users losing access to their wallets and risking legal action. In other jurisdictions, satisfying multiple regulatory requirements such as Know-Your-Client (“KYC”) and Anti-Money-Laundering (AML), as well as for tax reporting, can be onerous. As regulatory views continue to evolve, navigating regulatory uncertainties can also be challenging.

#### 5.4 RISK MITIGATION STRATEGIES

Users can use different mitigation strategies to protect themselves and manage their risk exposure. Many of the portfolio management strategies in traditional finance apply to DeFi but, unique in DeFi, users also must manage risks associated with smart contracts and custodial risks.

**Smart Contract Audits:** DeFi protocols are powered by smart contracts, which are written in computer code and deployed on blockchains. It is critical to examine the code and design of contracts to ensure they are resistant to hacks and attacks from malicious actors. Most protocols hire external code auditors to do testing and review. It is also important for users to review audit results as part of their research process before participating in DeFi platforms. Audit reports can be highly technical and inaccessible to the average user. Also, having completed audits does not mean the protocols are entirely safe. Many protocols have been exploited despite having performed security audits (Rekt, 2022).

**Bug Bounties:** Bug bounty programs invite and incentivize hackers and researchers to discover and disclose vulnerabilities in smart contracts and, therefore, protect against loss of users' funds. Immunefi, the leading bug bounty platform for DeFi, has over \$60 million of bounties available.

**Insurance:** Purchasing insurance, or “covers,” is one of the most straightforward and effective ways to protect against smart contract and custodial risks. We believe this is an area that both the industry and academia are falling behind in and urge that more resources should be allocated for studying this topic.

**Portfolio risk management strategies:** Hedging and diversification can be used to offset adverse price movements and manage risk and liquidity positions in DeFi. Spreading investments across multiple protocols is also a way to reduce the risk exposure to smart contract risks of specific protocols.

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<sup>16</sup> A Sybil attack is a type of attack on a computer network service in which an attacker subverts the service's reputation system by creating a large number of pseudonymous identities and uses them to gain a disproportionately large influence.

**Due diligence and own research:** None of the DeFi projects are risk-free, but some could be riskier than others. Retail and institutional DeFi users should always do their research before using new or experimental protocols or strategies. For the average user, DeFi Safety is often the first place to start, where DeFi protocols are independently reviewed and rated based on transparency and adherence to best practices.

## Section 6: Adoption of DeFi

It is not easy to measure the adoption of DeFi. Even though wallet activities can be analyzed, there is no limit on the number of wallets that an individual or entity can hold. A recent study estimated the total crypto population to be around 100 million (Wang, 2021). However, there are differences between the broader cryptocurrency ecosystem and the DeFi ecosystem. There were only about four million unique wallet addresses that had interacted with DeFi applications on Ethereum as of year-end 2021 (Dune Analytics, 2022), which implies a lower user count since each user can hold multiple wallets. The low number of DeFi users is not surprising since existing studies have shown that DeFi mainly attracts experienced cryptocurrency users and alpha-seeking investors (Chainalysis Team, 2021).

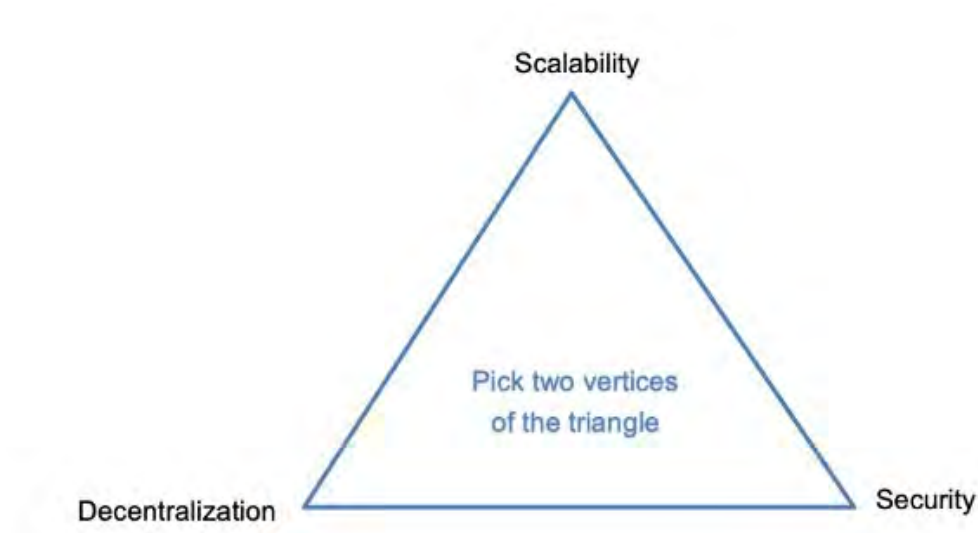
Network effects arise when the value of a product, service or platform increases with the number of people using it. Many of today's most popular companies are heavily influenced by network effects (Stobierski, 2020). The value of financial ecosystems will also increase as they scale and become more useful to users. To realize the network effect of financial activities, DeFi needs to attract and onboard many more users of all types. In the following sections, we discuss the existing barriers to the adoption of DeFi and some ways that DeFi can gain adoption and be further integrated with traditional finance.

### 6.1 EXISTING BARRIERS TO THE ADOPTION OF DEFI

**Scalability trilemma:** There is a major technical roadblock that must be solved before DeFi's mass adoption: the blockchain scalability trilemma. The blockchain scalability trilemma (Ethereum foundation, 2022) states that users can only achieve two of the following three desirable system characteristics: decentralization, scalability, and security. From a user's perspective, the scalability trilemma often manifests itself in congestion of a network and resulting expensive transaction fees. Optimizing all three is difficult; however, the scalability trilemma is only an observation rather than a mathematically proven fact. There may exist new consensus mechanisms (Rocket, Yin, Sekniqi, Van Renesse, & Sirer, 2019) and more complex blockchain designs (Buterin, Endgame, 2021) that could solve the issue. The technical details are beyond the scope of this report.

Figure 7

#### ILLUSTRATION OF THE BLOCKCHAIN SCALABILITY TRILEMMA



**Volatile crypto assets:** Substantial price drawdowns, or even total losses of cryptocurrency values, are commonplace. From 2017 to the end of 2021, Bitcoin suffered from several significant drawdowns (Lisa, 2021). The

prices of other crypto assets are highly correlated with the price of Bitcoin. While stablecoins do provide a peg towards the dollar and other fiat currencies, risk-averse investors find it difficult to search for less volatile assets with steady growth in DeFi.

**Unpleasant user experience:** Difficult technical specifications are one facet of the unwelcoming user experience in blockchain. Often investors are encouraged to “do their own research,” yet thorough understanding of DeFi protocols would often require technical knowledge inaccessible to many potential users. The tools necessary to participate in DeFi often do not work smoothly and could cause frustration. The interfaces of web3 protocols can also be challenging to use, yet customer support is typically not directly provided by the protocols, and users can only find support through user communities.

**Regulatory uncertainty:** It could be difficult to protect oneself from security and regulatory compliance risks. It is not reasonable to expect regular users to keep up to date with the current regulatory landscape. The uncertainty of future regulatory actions also increases the risk of investing in DeFi.

## 6.2 PATHWAYS TOWARDS ADOPTION

### Mainstream Adoption through FinTech

FinTech is new technology that seeks to improve and automate the delivery and use of financial services (Kagan, 2020). For example, DeFi wallet startup, Dharma Labs, offered an Ethereum wallet that allowed users to connect their bank accounts, and buy and swap tokens while engaging with other elements of the DeFi ecosystem (Matney, 2022). To attract users and improve their experience, DeFi needs services that can abstract away direct interaction with a blockchain and provide better education and customer service. The end game might be that users may not know that a blockchain supports the service they are using. FinTech firms, such as BlockFi, Celsius, Nexo, and Crypto.com, are leading providers of saving/lending products for stablecoins and other crypto assets. These centralized services are not necessarily DeFi-based, but they will bring awareness to the crypto space and accelerate adoption. The authors believe that FinTech firms will offer more DeFi based products, as well as provide a higher level of customer support services.

### Direct Product Offerings aimed at Institutions

Direct product offerings from DeFi protocols aimed at traditional investors, especially institutions, have also emerged. These products seek to provide investors with easier access to DeFi services. In June 2021, Compound Labs announced Compound Treasury, “designed for non-crypto native businesses and financial institutions to access the benefits of the Compound protocol” (Liu, 2021). What Compound Labs aimed to do was provide institutional access to DeFi yields, while abstracting away operational complexities. In January 2021, Aave launched a permissioned lending and liquidity service focused on attracting institutions called “Aave Arc” (Fireblocks, 2022). These services will simplify the investment process and allow more traditional investors to benefit from opportunities in DeFi.

### Tokenization of Real-World Assets

Tokenization is the process of issuing a token on a blockchain that represents a claim on an asset. Examples of tokenization of real-world assets include U.S. dollar pegged stablecoins and fractional real estate investments (RealT). Once tokenized, the asset tokens can then be traded, moved, or stored on the blockchain and used in DeFi applications. Further tokenization of real-world assets will increase the value of the DeFi ecosystem, allow for greater integration between traditional finance and DeFi, and unlock capital from real-world assets in DeFi. In June 2021, MarkerDAO started to allow tokenized real-world assets, such as tokenized freight shipping invoices, to be used as collateral for borrowing (Schmitt, 2021).

## **Institutional Uses of Blockchains**

Some organizations are conducting public blockchain experiments, paving the way for traditional institutions to participate in DeFi. In April 2021, the European Investment Bank (EIB) raised 100 million euros from a two-year digital bond on Ethereum (Bahceli, 2021). EY launched Baseline Protocol for businesses to perform private, secure transactions on public blockchains (EY, 2020). More recently, EY started to work with Polygon, a blockchain in the Ethereum ecosystem, to scale transactions for clients (EY, 2021). Deloitte has partnered with the Avalanche blockchain to provide a decentralized and transparent system that could improve state and local government recovery from natural disasters and public health emergencies (Deloitte, 2021). There is also on-chain evidence that innovative arms of large institutions are participating in DeFi. For example, Bain Capital Ventures is one of the top voters on Compound by voting weight (comp.vote, 2022).

Institutions are also experimenting with private blockchains which are not directly connected to DeFi. A private or permissioned blockchain can control, limit, and verify participants who can validate or use the blockchain. It will be interesting to watch how interoperability may be built between private and public chains.

## **Integration between DeFi and CBDC**

A Central Bank Digital Currency (CBDC) is a digital currency issued and backed by a central bank. CBDCs can be issued on a centralized ledger, which is a private database or distributed ledger such as a public blockchain (World Economic Forum, 2020). The existing DeFi ecosystem will have a heavy influence on the design of CBDCs, evidenced by references to DeFi in multiple reports exploring the topic (Allen, et al., 2020). CBDCs could be a direct substitute for stablecoins or co-exist with other forms of stablecoins. Regardless of the future market landscape, the authors' view is that the applications in the DeFi ecosystems today will likely remain relevant because they provide effective delivery of financial services with distinct characteristics from the traditional financial system, as discussed in Section 3. Additionally, the DeFi ecosystem allows various monetary policy experiments involving asset transfers and distribution of economic resources, and they could provide valuable lessons for global policymakers.



## Section 7: Implications for Actuaries

In this section, we will discuss the implications for actuaries in three categories. First, DeFi offers novel investment and risk management opportunities that could impact asset liability management over the long term. Second, emerging insurance applications require actuarial talent to flourish. Third, actuaries have the skillset to contribute to the general DeFi ecosystem.

### 7.1 PORTFOLIO MANAGEMENT

Actuaries work in a range of institutions that profit from investment activities. However, these (often heavily regulated) institutions are unlikely to participate in DeFi in the near future due to various factors such as relevant expertise, established risk appetites, regulatory and legal considerations, and accounting and taxation issues. However, that does not mean DeFi is irrelevant to actuaries.

As crypto and DeFi investments gain more traction amongst other institutions, the global monetary flow, as well as the supply and demand of traditional assets, may shift from the status quo. Institutions and retail investors with higher risk appetites may start to allocate capital into crypto and yield opportunities in DeFi and reduce their allocation for traditional assets offering safer yields. In a low-yielding market, this would be a welcome change for insurance companies. More generally, as the adoption of DeFi increases and the integration between DeFi and traditional finance intensifies, future successes and failures of DeFi could influence the traditional financial system and, thus, the performance of traditional asset classes. It would be wise for actuaries working in investment functions to start watching the development of this space and strategize accordingly.

### 7.2 INSURANCE APPLICATIONS

Insurance products in DeFi are increasingly popular amongst current users. Future investors, especially institutions, will also create more demand for insurance capacity for DeFi risks. This represents a great opportunity for innovative insurers. However, traditional insurers lack the expertise to identify risks and opportunities in DeFi, nor do they have the underwriting expertise to accept many of the risks. As DeFi continues to grow (and perhaps become increasingly regulated), significantly more capital can flow into the ecosystem. Actuaries are uniquely positioned to help solve the capability gap.

Beyond smart contract covers, decentralized insurance models can also be extended to other data-driven insurance products such as crop insurance and flight delay insurance. A parametric model, wherein pre-specified payouts are paid based upon a trigger event, can be implemented in a smart contract. This would allow automated claim processing. However, there are various challenges involved in offering traditional insurance products on blockchains, such as navigating licensing and regulatory requirements, and obtaining trusted real-world information from data providers or oracles. Despite the obstacles, projects such as Etherisc are underway to decentralize insurance applications.

### 7.3 WORK OPPORTUNITIES BEYOND INSURANCE

The DeFi ecosystem offers an abundance of job opportunities at every stage of the value chain. In addition to smart contract developers, the ecosystem needs economics researchers, business development experts, community managers, etc. The increasing number of people who work in crypto is evidence that talent migration has already started (Blandin, et al., 2020). It is expected that the talent war will continue to heat up as crypto adoption accelerates.

Actuaries have the numerical, analytical, and business skills to directly contribute to the development of the DeFi ecosystem, such as product design and engineering, analysis and design of tokenomics, and macro analysis of the DeFi ecosystem. High data availability on blockchains allows data analytics to be applied extensively across all

aspects of the industry. Actuaries can apply skills in data science and predictive analytics to study and simulate the behaviors of users, as well as to evaluate the performance of protocols. As the ecosystem matures, we expect to see more and more opportunities for actuaries to work in DeFi.



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## Appendix A: Glossary

<b>Airdrop</b>	Free tokens distributed by protocols for marketing purposes, with or without criteria to claim.
<b>Automated Market Maker</b>	A tool enabling automated trading without matching buyers and sellers by aggregating liquidity into a pool that traders trade against.
<b>Bonds</b>	Short-term vested protocol tokens sold at discount in exchange for LP tokens. Introduced by Olympus DAO.
<b>Burning</b>	The process of removing a token out of circulating supplies. Usually achieved by sending the token to a special address with an unobtainable private key, removing access to the token.
<b>Composability</b>	The ability for DeFi applications to communicate with and build upon each other.
<b>Consensus</b>	Agreement on a state of the blockchain in a network with multiple participants, or the mechanism to reach it.
<b>Custodial stablecoins</b>	Stablecoins whose value pegging mechanism is based on reserve assets held off-chain by the issuer of the stablecoin tokens.
<b>Decentralized Autonomous Organization (DAO)</b>	Organizations where governance token holders discuss proposals and vote to reach collective decisions.
<b>Decentralized Exchange (DEX)</b>	DeFi applications that allow cryptocurrency trading without an intermediary.
<b>Decentralized Finance (DeFi)</b>	An emerging financial system built on public and permissionless blockchains using smart contracts.
<b>Delegators</b>	Blockchain participants who delegate their cryptocurrencies as the equity rights to validators to ensure the integrity of transactions, thus earning a share of the fees without the need to invest in computational resources.
<b>ERC-20</b>	A smart contract technical standard on the Ethereum network for creating assets. Later adopted by other blockchains such as Binance Smart Chain and Avalanche.
<b>Ethereum</b>	A decentralized blockchain that first introduced smart contract functionality, with its native cryptocurrency Ether currently having the second largest market capitalization among all cryptocurrencies as of December 2021.
<b>Flash loan</b>	Smart contract enabled loan that is borrowed and repaid within the same transaction on a blockchain without collateral.
<b>GameFi</b>	An industry focusing on the gamification of monetary policies in play-to-earn games built on top of blockchains.
<b>Gas</b>	Computation and transaction fees paid by the transactor to be burned or to compensate miners and validators who help secure the network.

<b>Governance tokens</b>	Tokens that carry governance rights for a specific protocol. Usually these rights are realized by on-chain votes related to protocol decisions.
<b>Initial Coin Offering (ICO)</b>	The act of seeking money by creating a new token to raise funds.
<b>Initial DEX offering (IDO)</b>	The act of launching a new token on decentralized exchanges for trading.
<b>Interest-bearing tokens</b>	Tokens where the holders are entitled to interest, usually LP tokens.
<b>Interoperability</b>	The ability to move assets between different blockchains.
<b>Liquidity mining / Yield farming</b>	Providing liquidity for DeFi protocols for reward tokens, from a sharing of transaction fees or protocol equity tokens.
<b>Liquidity Provider Tokens (LP Tokens)</b>	ERC-20 Tokens that act as receipts for depositing cryptocurrencies into a smart contract that can be redeemed or used elsewhere.
<b>Non-custodial stablecoin</b>	Stablecoin whose value pegging mechanism is provided by a smart contract.
<b>Non-fungible tokens (NFTs)</b>	Tokens representing ownership of distinct digital valuables.
<b>On-chain / Off-chain</b>	Whether information or transactions are situated inside (on-chain) or outside (off-chain) the blockchain records.
<b>Oracles</b>	Services relaying off-chain information to on-chain applications.
<b>Permissionless blockchains</b>	Blockchains that are “shared by all network users, updated by miners (and validators), monitored by everyone, and owned and controlled by no one.” (Swan, M. 2015. <i>Blockchain: Blueprint for a New Economy.</i> )
<b>Private keys</b>	Secret information used to verify the ownership of cryptographic assets.
<b>Protocols</b>	An application or a group of applications built on blockchains.
<b>Scalability trilemma</b>	The theory that it is difficult for a blockchain to achieve scalability, security and decentralization.
<b>Slippage</b>	The value lost in trading with automated market makers due to price movements from the trade itself.
<b>Smart contracts</b>	Systems which automatically move digital assets according to arbitrary pre-specified rules. (Buterin, Ethereum Whitepaper, 2013)
<b>Stablecoins</b>	Tokens whose value is pegged to fiat currencies.
<b>Tokens</b>	Value-storing digital records of equities, utilities, or other functions enabled by smart contracts. Loosely interchangeable with “coins” in blockchain contexts and “cryptocurrencies.”
<b>Tokenomics</b>	The study of the economics of crypto tokens.
<b>Total value locked (TVL)</b>	A measure of protocol size by the amount of capital deposited into the protocol’s smart contracts.

<b>Validators</b>	Blockchain participants who are responsible for verifying the integrity of transactions.
<b>Web3</b>	A new generation of the Internet that decentralized the online ecosystem based on blockchain with token-based economics.
<b>Yield Aggregators</b>	Decentralized apps that pool tokens from different users to perform yield farming transactions in a batch to save time and gas fee costs.

## Appendix B: A Brief History of DeFi

How did blockchain technology give birth to DeFi? In this section, we provide an overview of the history of DeFi and how it evolved to be a vibrant ecosystem.

### Ethereum and Smart Contracts

In late 2013, Vitalik Buterin, then an expert in Bitcoin and blockchain technology, introduced Ethereum to the world in a white paper titled “A next-generation smart contract and decentralized application platform.” Launched in 2015, Ethereum is a blockchain created for building decentralized applications that allow for “rapid development time, security for small and rarely used applications, and the ability of different applications to very efficiently interact.” One design principle of Ethereum is “universality” in that the protocol provides a Turing-complete scripting language that programmers can use to write and execute any smart contracts that can be mathematically defined. In essence, Ethereum is a decentralized world computer that anyone can use to deploy smart contracts and interact with applications built on top of it.

In his initial white paper, Buterin envisioned that financial applications would be an important category of applications on Ethereum, and described concepts behind on-chain token systems and financial derivatives.

### MakerDAO and Stablecoin Dai

One of the main issues with cryptocurrencies like Bitcoin is their high price volatility, which means their uses would be primarily limited to basic transfers, store of value, and speculation. Stablecoins were invented to curb this problem. Stablecoins are crypto assets that are pegged to the U.S. dollar and other fiat currencies. The Maker project was started by Rune Christensen and other blockchain contributors with the goal of creating a decentralized stablecoin on Ethereum.

Using the Maker protocol, users can mint Dai, a stablecoin, from an overcollateralized loan, similar to a repo market transaction. If the value of collateral falls below a predetermined threshold, the position can be liquidated to pay off the loan. At any point in time, the protocol is holding sufficient collateral to back the Dai in circulation.

The Maker protocol is governed by the MakerDAO, a decentralized autonomous organization where governance token holders, instead of a central authority, can vote to make changes to the parameters, collateral types, and operations of the protocol.

The first version of Dai was launched on Ethereum in December 2017. The invention and successful launch of stablecoins unleashed the potential of blockchain-based financial applications. The Maker protocol remains popular and impactful to this day.

### The DAO Hack

Decentralized autonomous organizations (DAO) are organizations on blockchains that enable decentralized control and decision-making by their members using smart contracts. In 2016, the “DAO” was invented to work like a decentralized venture fund, through which its token holders would vote on how to allocate its crowdfunded capital. The DAO was a prominent project at the time with \$150 million raised through its token sales. It was, unfortunately, hacked and led to a hard fork<sup>17</sup> of the Ethereum chain to revert the damages. The hard fork was highly controversial and led to a split of the chain into Ethereum (ETH) and Ethereum Classic (ETC). Despite the death of the DAO, the

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<sup>17</sup> A hard fork, as it relates to blockchain technology, is a radical change to a network's protocol that makes previously invalid blocks and transactions valid, or vice-versa. [<https://www.investopedia.com/terms/h/hard-fork.asp>]

ideas behind it lived. Over time, DAOs became a popular and practical way of governing many decentralized protocols.

### **The ICO Craze**

In late 2016 and throughout 2017, Ethereum became a popular fundraising platform via Initial Coin Offerings (ICOs). Startups were selling tokens to raise money to bootstrap their blockchain projects. ICO provided an alternative to traditional financing routes through banks and venture capital firms because it was easier, faster, and unrestricted. The lack of regulation was a double-edged sword as many overhyped projects and even outright scams were raising funds through ICOs, giving ICOs a bad reputation. Regulator intervention, rampant scams, and lack of real, unspeculative use-cases of crypto assets eventually led to the crash of the entire crypto market in 2018 and ended the ICO mania.

Despite all the negatives, there were several meaningful developments: First, the Ethereum blockchain became battle-tested and proved its security by processing high volumes of competing transactions and withstanding numerous attacks from hackers trying to break the network. Second, the ICOs attracted a significant amount of capital and users and created a strong network adoption effect for Ethereum. More users gained familiarity with Ethereum wallets and smart contracts than ever before. Third, several protocols, including Aave, Bancor, and Ox, that raised funds from ICOs ended up becoming successful later in the movement of decentralized finance. As observed in every hype cycle in the past, 99% of the projects failed. However, the remaining 1% will rise from the ashes and change the world for the years to come.

### **Accumulation and Development of Decentralized Application**

Despite the collapse of ICO mania and crash of the price of ether, the Ethereum network continued to attract developers to build decentralized applications. From 2017 to 2019, many applications were launched on Ethereum. Uniswap, a popular on-chain decentralized exchange was developed and launched during 2017-2018. Compound, a lending protocol that allows users to borrow and lend crypto assets, was also developed during the same period. Through algorithmically, autonomously adjusted interest rates, Compound created liquid money markets for crypto assets in a decentralized manner. Existing protocols continued to evolve, in particular, Maker started to accept collateral other than ether in 2019.

### **Liquidity Mining and Rise of DeFi**

It wasn't until the summer of 2020 that Compound gained significant traction. In June 2020, Compound started to distribute its governance token COMP to its users to incentivize supplying and borrowing assets. The token distribution quickly attracted users and on-chain actions for earning the token rewards, an activity known as liquidity mining. Many other protocols followed suit. It kicked off what became known as "the DeFi summer" in 2020. The landscape of DeFi is constantly evolving. Contributors are busy tackling the scalability trilemma through roll-ups, modular designs, and new consensus mechanisms. Uses of multiple blockchains have become increasingly popular. The web3 revolution is gaining traction and expanding its reach. The full potential of DeFi has yet to be unlocked.



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